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Standard Fungicides and Insecticides in Agriculture

WITH NOTES ON . . .
CHARLOCK DESTRUCTION

SECOND EDITION

By G. F. Strawson

LONDON
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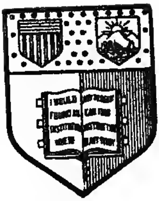

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Standard Fungicides and Insecticides in Agriculture

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BY

G. F. STRAWSON

AUTHOR OF 'INSECTS AND FUNGI INJURIOUS TO PLANTS, WITH REMEDIAL TREATMENT'

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BEYOND the general public who may take up this little book, I have reason to think it will fall into the hands of that small band of workers, few in number and thinly scattered over the world, who tread the unfrequented path that I have trod, a path that does not lead to public acknowledgment or reward, but to a higher compensation, a consciousness of having in some degree advanced those beneficial principles which cannot be erased even by the advancing hand of Time.

PREFACE

TO

THE SECOND EDITION.

THE two and a half years that have elapsed since the publication of the first edition of this book have brought fresh knowledge and experience to bear upon some of the unsolved problems in connection with fungicides and insecticides.

It is gratifying to note that the object of the first edition of this book has been largely realised, the principles laid down have been widely adopted, and old and unscientific formulas are fast disappearing.

The two new words 'SPRAYFLUID' and 'SPRAYMARKER' introduced to emphasise special objects have proved useful in enabling fungicides and insecticides to be applied more easily and effectually.

In standardising fungicides and insecticides the examples given are such as may be relied upon for general use, but it is by no means claimed that any are perfect—though they are probably up to date. The more important point, I think, is attained—viz. that they are described so as to be obtained or made with accuracy, and will be of uniform quality wherever they are used.

G. F. S.

LONDON: 1906.

INTRODUCTORY.

1. This little volume is written in the hope that some things in it will be found useful, not only to those who require to put into practical working the various formulæ and principles laid down, but also to lecturers and students, as well as to those writers who have occasion to issue short pamphlets, leaflets, or chapters upon this subject for public information.

I entered upon this task at the suggestion of some friends who are amongst the most practical agricultural teachers of the day, and my first intention was to prepare a larger book on the standardisation of fungicides and insecticides with details of their application for various plant maladies. The latter part I regret being unable to deal with at present,[1] owing to a constant pressure on my time. Therefore I venture to issue this first part dealing with 'Standardisation,' as it is a subject unquestionably needing urgent attention, and will clear the way for the second part of my task.

The number of fungicides and insecticides dealt with includes those only that have been proved on a large scale to be valuable and are adopted in practice. This number is at present small, and does not include several materials and formulæ which are undergoing trial but have not yet arrived at the point at which they could be placed on the list of standards. Writing from a wide practical experience, I have treated this subject with a free hand, suggesting such standard strengths for all materials as, in my opinion, are likely to prove most effectual and suitable for general acceptance, and offering such advice and criticism as may prove useful.

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[1] Since published, *Insects and Fungi* (Simpkin, Marshall & Co., London).

Amongst the new features that I am introducing are two requiring new names—'Spraymarker' and 'Sprayfluid'—both of which I suggest as useful and worthy of adoption. Another new subject which I regard as extremely important is the introduction of a new, simple, and inexpensive method of dealing with the worst of all classes of plant pests, viz. those that attack directly or indirectly from the soil. The wireworm comes under this class and is controlled by it, as well as the *Phylloxera vastatrix* and others. The value of a simple, successful, and cheap process to check these pests which decimate the cheaper cultivations will be appreciated, and, I trust, soon generally adopted in practice. Finger-and-toe in turnips and some other fungous diseases below ground may probably succumb to similar treatment.

I may have imperfectly described several of the points I wished to make clear, but hope that counterbalancing advantages will be found in original matter. Some of the observations I have made may be thought to be too obvious and simple to need recording, but it should be remembered a work of this kind is not undertaken for one district only, but for the varying requirements of all who cultivate plants.

The standardisation of insecticides and fungicides will, it is hoped, clear away the mists surrounding many of the current formulæ and promote between growers a more intelligent and useful comparison of their work, as it is mainly by such comparisons that improved treatment is developed and effectual progress obtained.

Without presuming to give a history, it may be useful to note that the practice of applying fungicides and insecticides on an extensive scale in agriculture and horticulture for controlling the maladies to which cultivated crops are liable is of quite recent origin. Twenty years ago it was in its infancy, although millions of acres of the more expensive crops are now annually treated with success by the more enterprising cultivators, and many millions of pounds' worth of crops saved annually that were lost under the old system. Although much has been accomplished, far more still remains to be done. Such progress is being made in all branches of this subject that it seems probable that this new science upon the threshold of which we are now entering is likely to become one of the most conspicuous landmarks in the history of agriculture in the present century.

On vines, fruit trees, tobacco, cotton, potatoes, and a few other crops an excellent beginning has been made ; but these form only a small portion of that vast expanse of cultivation that clothes the world with green, from the lowest grass to the tallest tree, and all are subject to maladies and are waiting relief. That means of relief will eventually be discovered cannot be doubted by those who are acquainted with what has already been accomplished. To promote the knowledge of those useful operations which have proved successful beyond anticipation, to develop into practical form suitable treatment for subjects not yet dealt with, to improve older methods, and to counteract some of the popular errors and prejudices that exist, are objects that afford unbounded scope and fascinating work.

Comparing only ten years ago with the present time, a great change is noticeable. Then darkness, misconception, and prejudice appeared (with few exceptions) on every hand against these innovations. Now the darkness is changing into dawn, the misconception and prejudice are weakening, and the irresistible light of successful practice shines brightly and compels acknowledgment. On every hand there are still investigations to be made, problems to be solved, principles to establish, and processes to develop—work affording a magnificent field for the energies of those who have leisure and means at their disposal.

ON
FUNGICIDES AND INSECTICIDES

GENERAL OBSERVATIONS.

2. *Nomenclature.* — The present condition of the nomenclature of fungicides and insecticides is scarcely satisfactory. The employment of local terms and names frequently leads to confusion. There is really no need for this, as all the substances employed are products known under definite names in commerce, and the same names are usually well known to scientists. It is therefore better to avoid all local names and synonyms and employ only such terms as can leave no doubt as to what material and quality are intended. Where the strength of commercial articles varies, the strength intended should always be mentioned, especially in such cases as potassium cyanide, caustic soda, potash, &c.

The following names and terms occur to me at this moment as undesirable :—

1. ‘Copperas,’ ‘bluestone,’ or ‘blue vitriol,’ instead of copper sulphate.

2. ‘Caustic alkali’ for caustic soda.

3. ‘Concentrated lye’ for potash, or the word ‘crude’ if intended to apply to a chemical of definite strength, *e.g.* crude potash, the potash strength and quality of which is unknown.

4. ‘Gill,’ ‘tablespoonful,’ ‘wineglassful,’ or ‘cupful,’ instead of a definite fluid measure.

5. ‘A quart’ of soft soap instead of a definite weight.

6. The word ‘wash’ for a spraying liquid or ‘sprayfluid.’

7. The use of the word ‘solution’ for mixture, as in the case of ‘Paris green’ and water, or Bordeaux mixture, where the active principle is insoluble.

Accuracy.—In treating the maladies of plants by means of fungicides and insecticides it is obvious that a reasonable approach to accuracy should be observed in the preparation of the materials employed. It is difficult at times to obtain materials of the exact strength or quality required, but there is no excuse for using indefinite names for these when names accurately defining the materials might quite as easily be employed.

Commercial Materials.—For economical reasons many common commercial substances must be used in fungicides and insecticides that vary considerably in quality, and are not of the standard strength required. In such cases the strength or percentage of purity of these common articles should be ascertained, and a calculation made, how much more or less of such articles must be used to give the preparation the desired strength. This should be thoroughly understood, for the chief object I have in view in these pages is to inculcate greater uniformity in the preparation of remedies adopted in the treatment of plant maladies.

Percentages.—It must be quite apparent that when a prescription orders a chemical of definite strength, either that strength must be obtained to make up the formula properly, or more or less of a weaker or stronger chemical must be substituted to make the strength equivalent. For example, say 4 lb. of a 75 per cent. chemical is ordered, but only a 60 per cent. chemical of that kind is obtainable, then a larger quantity must be employed, and in this case 5 lb. of the 60 per cent. would be required to equal the 4 lb. of the 75 per cent. article.

Obsolete Names.—It is most desirable to discontinue the use of all obsolete and local names and such as are indefinite or little understood. As an example of indefiniteness take 'Crude Potash.' Can anyone tell the quality or strength of 'Crude Potash'? It may be a carbonate of potash or it may be a caustic potash or a mixture of the two, and the potash strength may be anything from 10 per cent. to 98 per cent.

Undefined Materials.—Besides the materials that are sold of known strength there are some which are necessary, the valuable properties of which cannot be easily ascertained except by actual experience. Such are Hellebore, Pyreth-

Missing Page

Board of Agriculture, as the slight alterations made in it since I last reviewed it shows the Board of Agriculture is travelling backwards instead of forwards, and further experience has brought to light more evidence of the mischief this leaflet is doing.

Shortly, this Leaflet No. 70 *is stated to be for the winter washing of fruit trees, and is partly recommended for removing from trees vegetal incumbrances, such as moss and lichens, and partly for destroying insects harbouring upon them, and also for attacking the eggs of certain insects, although its action in the latter case has not been fully determined, but that groups of the eggs of the apple-sucker and the red spider were all killed with it.*

Now let us see what the Board recommends to accomplish these most desirable objects and destroy the evils, some of which are causing orchards to be unprofitable.

Omitting unnecessary details, the two active materials named are—

1 *lb. of Commercial Caustic Soda,*

1 *lb. of Crude Potash* (*or 'potashes' or pearl ash*),

which are dissolved in water to make up 10 gallons. Both these are of indefinite strength. Commercial caustic is of all strengths, as high as 98 per cent., and as low or lower than 48 per cent., but there is no information given as to the best strength to use for this purpose. However, this is supposed to be explained in a luminous footnote on the leaflet as follows :—

> *The amount of pure caustic soda in commercial caustic soda varies from 50 to 98 per cent. The actual percentage for use on this wash does not matter at all, as the 98 per cent. is not injurious to the trees, and 50 per cent. will clean off moss and lichens. The wash has frequently been used at double the strength given, but this is, however, unnecessary.*

This amazing statement—that it 'does not matter at all'—is very characteristic. For it not only does matter, but it is well known that the high causticity of the liquid used is the essential point in destroying the worst pest that it is used for; and, if that were not so, it would be better, for the sake of economy, to use 50 per cent. soda, as the cost, when bought in quantity, is in proportion to the percentage of pure caustic soda.

The other active ingredient is 'crude potash,' a still more indefinite article. It is perfectly safe to say that no one, either inside or outside of the Board of Agriculture and Fisheries, knows what is the correct composition or the correct potash strength of 'crude potash.' There is no known definite quality or strength for it. Any rough material containing 10 to 98 per cent. of potash, whether in the form of caustic potash or carbonate of potash, or a mixture of both, might be properly sold as 'crude potash'; and yet this crude potash is recommended in a leaflet supposed to contain scientific information.

Instead of crude potash, potashes or pearl ash, it is stated, may be substituted. Both these articles are also of indefinite potash strength, and both usually contain a varying proportion of carbonate of soda. There is no guarantee given with either when purchasing. I have known a sample of pearl ash to contain 80 per cent. carbonate of potash. But this, I think, is exceptionally high.

The most important of all objects for which this caustic liquid is now used is to destroy the eggs of the apple-sucker (*Psylla mali*). There is no other practical method known of keeping this serious pest in subjection except destroying it in the egg. It is now known that a solution of caustic soda and potash of a definite strength will invariably destroy the eggs of this pest. I have mentioned this in my recent work, 'Insects and Fungi on Plants,' and it is confirmed by the experience of others. This knowledge has been obtained by the use of more exact and scientific methods than those disclosed in Leaflet No. 70. It is not surprising that the leaflet says: 'The extent of its action on the eggs has not, however, been fully determined.' It is very doubtful if it ever would have been determined had it depended upon the 'strength-does-not-matter-at-all' formula of the Board of Agriculture and Fisheries.

Another Example.—Since commencing this article, another leaflet has come into my hand.

It is issued by another authority. This leaflet appears to be an abridged and slightly altered edition of the Leaflet No. 70 of the Board of Agriculture and is intended for similar purposes.

The active ingredients advised for ten gallons of liquid in this leaflet are—

1 *lb. Commercial Caustic Soda,*
1 *lb. Crude Potashes.*

No indication of the chemical strength of either of these articles is given. That is left to accident. The criticisms I have applied to Leaflet No. 70 equally apply to this Leaflet.

Conclusion.—I have given considerable space to these examples of what is still being circulated as scientific and practical information. I might have followed with examples in other directions, but I think I have sufficiently fulfilled my duty to growers and teachers for the present by pointing to examples of unscientific formulas that lead cultivators into waste of time and money only to obtain results as indefinite and uncertain as the material they are advised to use. The views I have expressed I am solely responsible for, but I know they are shared by the most experienced scientists and cultivators.

'SPRAYFLUIDS.'

3. In proposing the new name 'sprayfluid' for all liquids prepared for the specific purpose of spraying plants, I am only defining a need that must have been felt by all whose experience has been on an extended scale. My friend the late Dr. C. V. Riley, of Washington, with whom I had the advantage of discussing this matter, had already found it necessary to use some such distinction, and had classed all such liquids as 'sprays': a word, I think, unfortunately chosen, as the same word has always been used and is admirably suited in describing the little clouds of spray which issue mechanically from the spray nozzle.

'Sprays' in this sense may be usefully classified for reference as follows:—

(*a*) A fine spray is a misty, dew-like spray.

(*b*) A coarse spray is a spray like fine rain.

(*c*) A light spray refers to the quantity of spray, say 30 gallons per acre applied to a low ground crop.

(*d*) A heavy spray would represent 80 or 100 gallons per acre sprayed on a similar crop and area.

To describe liquids used for spraying as 'sprays' or 'washes' inevitably leads to confusion, while the word 'sprayfluid' has a specific and unmistakable meaning.

Those who have had the responsibility of spraying large areas are fully aware of the necessity of having the sprayfluid as perfect as possible, whilst beginners in field-spraying not uncommonly fall into the error of attempting to spray with a liquid that is not properly prepared as a sprayfluid. Such attempts have not infrequently led to the regrettable failure of a demonstration in public. A sprayfluid cannot choke the orifices through which it has to pass, and renders the work of spraying continuous and easy, and defined as follows should prove useful in practice.

Definition of a Sprayfluid.—A sprayfluid is a limpid liquid so prepared and maintained that it is free from all solid or semi-solid particles that can obstruct the easy passage of the liquid through the small orifices of the spraying machine. A sprayfluid ceases to be a sprayfluid the moment it becomes contaminated.

The advantages of a sprayfluid are conspicuous in the field by the evenness of its distribution, the facility with which it is applied, and the absence of those annoying difficulties which I think fully justify the adoption of the new word, which I have observed is now being used by many of the best writers and growers.

‘SPRAYMARKERS.’

4. After spraying vines or potatoes with the insoluble copper compounds it will be noticed that while the spray is still wet the spray-marks are scarcely distinguishable on the leaves, but as soon as it is dried they are very conspicuous and exactly indicate the fineness of the spray, the quantity applied, and its distribution, and give a perfect record of the quality of the work done. In this case the spray is self-marking, but in the case of Paris green sprayfluid and others there is practically no mark of the spray left on the plant even when dry, and it is impossible to trace exactly where the work has been done or left undone, nor is the quality of the work or the quantity of material applied indicated by any marks. It is to remedy this uncertainty that I have devised a compatible spraymarker to each sprayfluid, except those that are self-marking.

Those spraymarkers which I have selected in no way interfere with the active ingredients employed, are easily obtainable, and cost practically nothing more than the trouble of mixing. With those materials that have a powerful effect on the plant (as Paris green on the leaves) the adoption of spraymarkers will be found extremely serviceable, and fully justify the introduction of a new and distinctive word.

A suitable spraymarker will be given with each 'standard formula,' and it merely requires to be mixed with the sprayfluid in the small quantity sufficient to cause a well-defined mark being made with every minute particle of the sprayfluid.

MISCELLANEOUS NOTES.

5. These notes may appear to some to be too obvious to need recording, but there is a large class of cultivators whose attention may be profitably directed even to such elementary matters.

Weights and Measures.—As confusion often arises from the use of local or obsolete names for weights and measures, it should be understood that only the Imperial weights and measures are intended in this book, and all solids are calculated by weight and all liquids by measure, unless stated expressly to the contrary. When the specific gravity of a liquid is known, either weighing or measuring may be adopted with equal accuracy. In practice it frequently happens that it is more convenient to weigh than to measure the following liquids, and their weight in comparison to measure is given and is sufficiently accurate for general use:—

1	gallon of	vegetable fixed oil or fish oil weighs	9 lb.
1	,,	kerosene oil	8 ,,
1	,,	water	10 ,,

Percentages.—The strength of a solution is very conveniently expressed in percentages, thus a 5 per cent. solution means that 100 parts of the solution will contain 5 parts of the chemical.

As 10 gallons of water weigh 100 lb., it follows that if 1, 2, or 3 lb. of any chemical is dissolved in sufficient water to make 100 lb. the result will be a 1, 2, or 3 per cent. solution of the chemical, and so on.

It is both convenient and accurate to express strength of solution by percentage, and I think where it is necessary to diminish or increase the strength, it might be done as often as possible in 10 per cent. units, which are convenient for reference and comparison.

Equivalent Strengths.—It is important to clearly understand this definition, as commercial chemicals constantly vary in the percentage of the pure chemical they contain. When the chemical obtainable is weaker or stronger than that prescribed, it is necessary to use more or less of it, so as to make the strength of the solution equal to what it would have been if a chemical of the prescribed strength had been used.

Cost of Materials.—The cost of materials varies in all countries and is subject to constant fluctuation. The business man requiring them will probably know best how to obtain them economically, and when estimating the cost the form in which the material is supplied must be considered. When a material can be supplied in a convenient form, either half or wholly prepared ready for use, it is frequently worth 50 per cent. more to the user than the raw materials. In purchasing, first decide exactly what is required, and give a written order defining the strength of quantity of the article, employing the proper names and not the local or obsolete names.

In the case of such a material as pyrethrum and hellebore, the quality of which must be largely left to the seller, the only plan is to buy of the most trustworthy dealers.

With the important proprietary articles, they should always be obtained direct from makers or their responsible agent, and so avoid the mischief of substitution.

STANDARD
FUNGICIDES AND INSECTICIDES.

The previous matter should be read in explanation of these formulæ.

6. Hydrocyanic Acid Gas.*

This gas is the most powerful and dangerous poison used for insecticidal purposes. Its employment should therefore only be entrusted to well-instructed and careful operators.

The process consists of submitting the plants to the influence of an atmosphere of the gas in an inclosed space, such as a tent or glasshouse. The gas is usually generated from cyanide of potassium or sodium cyanide, and the proper quantity of gas to employ per cubic foot of space is regulated by the weight of the cyanide used. The general practice adopted is to use 1 oz. of cyanide for every 150 cubic feet of inclosed space. This simple proposition would need no comment if the commercial cyanide employed was only of one strength; but as it is sold of all strengths from 30 to 98 per cent., it is obvious that all strengths of cyanide cannot be adopted as suitable to a given cubic space. Unfortunately, few writers give the strength of the cyanide used in the operations they describe, which increases the difficulty of standardisation, and for this reason it may be well to give some notes in support of the 'standard' strength which I suggest should be adopted.

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* A full description of "Fumigation" by hydrocyanic acid gas and an improved method of applying it is given in *Insects and Fungi*, Strawson (Simpkin, Marshall & Co., London).

Commercial potassium cyanide varies from 30 to 98 per cent. purity. The following strengths are actually known to the writer: 30, 40, 45, 50, 60, 70, 89, 91, 94, and 98 per cent., and there are others. Ten years ago 45 to 50 per cent. was the ruling strength, whilst 60 to 70 per cent. was generally obtainable in commerce.

Some writers mention 60 or 70 per cent. as having been successful, and from the wide distribution of these percentages a few years ago it is highly probable these cyanides have been generally used, and with satisfactory results, when 1 oz. has been employed for every 150 cubic feet of inclosed space.

The improvement in the manufacture of cyanide (resulting from its large employment in gold recovery) has gradually crept up, and now a 98 per cent. is likely to supersede all others and be most universally obtainable. These reasons appear sufficient to justify 98 per cent. cyanide, when used in proper proportion to the cubic space, being substituted for the 60 or 70 per cent. formerly employed. I therefore suggest the following as a standard for generating an atmosphere of hydrocyanic acid gas for plant fumigation.

Take of—

Potassium cyanide 98 per cent. (or its equivalent strength)	1 oz.
Sulphuric acid (Sp.G. 184, or its equivalent strength)	1½ fl. oz.
Water	4 oz.

for every 200 cubic feet of inclosed space.

The water is placed in an earthenware jar and the acid slowly and carefully poured into it. In a separate shallow earthenware dish place the cyanide. The next operation is to bring the acid and cyanide together without the risk of inhaling any of the poisonous gas that is immediately liberated. The dish of cyanide is placed on the ground, and the jar of acid is arranged in such a position near it that by means of a simple device leading to the outside of the tent the acid can be slowly poured into the cyanide. When all is ready every opening into the tent is closed, and the acid and cyanide gradually mixed.

Hydrocyanic acid gas is instantly disengaged with effervescence and spreads through the structure, which should remain tightly closed for 40 to 60 minutes, when the ventilators or doors may be cautiously opened, and the remaining gas allowed time to escape and thoroughly clear off before anyone is allowed to enter.

In the past hydrocyanic acid gas has been obtained from potassium cyanide for insecticidal use, as above described, but in the near future it is not unlikely that sodium cyanide will be its source, as this chemical has recently acquired commercial importance in gold recovery.

Sodium cyanide is known commercially as 130 per cent. strength when compared with potassium cyanide 98 per cent.; therefore only about three-quarters the weight is necessary to produce an equal amount of gas. It possesses all the advantages of potassium cyanide, and is cheaper in proportion to the amount of gas it yields and very convenient to use.

For reference when other strengths than 98 per cent. cyanide are employed the following (approximate) table will be useful:—

3·27	oz. of	30	per cent.	potassium cyanide	Are equal to 1 oz. 98 per cent. potassium cyanide.
2·45	,,	40	,,	,,	
2·18	,,	45	,,	,,	
1·96	,,	50	,,	,,	
1·63	,,	60	,,	,,	
1·4	,,	70	,,	,,	
1·22	,,	80	,,	,,	
1·09	,,	90	,,	,,	
			and		
0·75	,,	130	,,	sodium cyanide	

Any other strengths in proportion.

7. Carbon Bisulphide.

A volatile and highly inflammable liquid, and solvent for sulphur and naphthalin. This extremely useful insecticide is employed for the vapour which it emits. Its operation is analogous to fumigation. The vapour must be confined in the space occupied by the insect, as in the case where the bisulphide is injected into the soil to destroy root-feeding insects, as in *Phylloxera vastatrix* on vine roots, where its beneficial effects have been incalculable.

The employment of bisulphide on large areas is limited on account of its cost and the necessary method of application; it can therefore only be used on the more valuable crops, and requires great care in application, as an excessive dose may prove injurious to the plant. The principle upon which bisulphide acts is one in which I feel much interest, as I am firmly persuaded that in this direction far greater advances are likely to be made in future in dealing with soil insects than have ever been made in the past.

I shall refer to this subject more fully when I come to refer to a new form of insecticide, which for a short name I propose to call 'Vaporite (Strawson).' See p. 57.

8. Caustic Soda.

Synonym:—Sodium hydroxide.

Caustic soda is a powerful alkaline caustic, soluble in cold water and in alcohol, and deliquescent on exposure to the air. It rapidly cauterises the skin, producing painful sores, and care should be exercised in handling it. Commercial caustic soda, one of the largest products of the chemical industry of Britain, is for certain manufacturing purposes distributed in large quantities throughout the world, but in the smaller quantities required in fruit-growing districts it is not always easily obtainable. The most convenient form of buying caustic soda for fruit growers is in small iron cans of from 1 lb. upwards, so that the whole contents of the can may be used at one time.

When purchasing caustic soda it is highly important to ascertain the exact quality supplied. Commercial caustic soda for economic reasons is made of various degrees of strength, varying from 48 to 98 per cent. These different qualities cannot be used indiscriminately in making up formulæ for spraying trees without serious disadvantages. It is therefore necessary to fix some standard for the strength of the caustic soda which should be employed for this purpose.

I have met with no literature that solves this highly important question. The lighter class of writers such as I have referred to, p. 13, merely prescribe ‘commercial caustic soda’ without any reference to the strength. More practical men name the strength they have used, some giving one strength and some another, which, unfortunately for the purpose in hand, includes every strength from 48 to 98 per cent. In this difficulty I shall rely upon my personal knowledge of the subject in proposing commercial caustic soda 70 per cent. (or its equivalent) as the standard for fungicidal and insecticidal work, and am guided to this conclusion by the following reasons: (*a*) In practice I have found a solution of 1 lb. of 70 per cent. soda in 10 gallons of water may safely be applied to dormant trees without fear of injury; (*b*) a 70 per cent. soda is widely distributed and generally more easily obtained by growers; (*c*) a 70 per cent. soda has been chiefly used in developing its application to plants, and has been successfully employed by some of the most practical men, including my friend the late C. V. Riley, of Washington.

It was probably from the convenience of obtaining 70 per cent. soda that it was chiefly used in the development of soda spraying, and although the same reason may still apply it does not debar other strengths of caustic soda being used in proper proportion to make up the equivalent of 70 per cent.

The following table shows (approximately) the quantities to be used of other caustic sodas as substitutes for 70 per cent. soda:—

23¼	oz. of	48	per cent.	Are equal to 1 lb. of 70 per cent. caustic soda.
22½	,,	50	,,	
18½	,,	60	,,	
14	,,	80	,,	
12	,,	90	,,	
11½	,,	98	,,	

Other strengths in proportion.

Caustic soda is generally used in connection with potash as a sprayfluid on dormant fruit trees and bushes, and every twig, as well as the stem and branches, should be well wetted. It operates as an insecticide on living insects, and also destroys many insect eggs that it comes in contact with, and at the same time kills the moss and lichen on the bark and gives the tree a healthy and clean appearance. For merely clearing the trees of moss and lichen a solution of caustic soda (1 lb. in 10 gallons) alone is sufficient. It is generally desirable to go further than this and to destroy the insect eggs and living insects that infest the bark and interstices of the trees, and for this purpose the addition of potash is recommended.

9. Soda and Potash Sprayfluid.

The following may be regarded as a standard for soda and potash sprayfluid :—

Caustic soda 70 per cent. (or its equivalent) . .	1 lb.
Carbonate of potash 80 per cent. (or its equivalent)	1 lb.
Soft soap (8 per cent. potash)	½ lb.
Water to make up 10 gallons.	

A vessel capable of holding 10 gallons or more is partly filled with water, in which the soda and potash are dissolved, adding the soft soap (previously dissolved in hot water) and sufficient water to make up 10 gallons.

Spraymarker.—Whiting (carbonate of lime).

Taking this as a safe standard for general use, on the hardier trees the quantity of soda and potash might often be increased with advantage by 25 or even 50 per cent., but it is unnecessary to increase the weight of soap in proportion.

10. A New Formula and New Standard for Soda and Potash Sprayfluid.

The use of commercial caustic soda for making soda sprayfluids has become an established custom, and for the sake of those who prefer to continue its use I have given it a lengthy notice. I propose a new formula which I have designed for making soda and potash sprayfluid which introduces carbonate of soda (commercial soda crystals or washing soda) as the index of strength of the solution instead of the solid commercial caustic soda. The new formula will, I think, promote greater uniformity of strength and facilitate its preparation.

The commercial soda crystals or washing soda is a carbonate of soda of one strength, namely, 98 per cent., and therefore gives a reliable uniformity to the strength of the solution of caustic soda produced from it.

The advantages claimed for the new formula are chiefly :—

(*a*) The ingredients are all well known in the homestead, and may be obtained in every village.

(*b*) The commercial soda crystals are of one strength, 98 per cent., and therefore give reliable uniformity to the strength of the solution of caustic soda produced.

(*c*) As the caustic soda in this formula is only produced in a largely diluted condition in the liquid, any risk or inconvenience in handling solid caustic soda is avoided.

(*d*) Solid caustic soda is not so easily obtained in country districts, and when obtained it is commonly impossible to get even an approximate guarantee of its strength.

(*e*) The formula gives both the soda and potash in the caustic form and of very uniform strength.

(*f*) The solution can be used as a clear liquid, or combined with a spraymarker by merely stirring up the lime.

It is made as follows, and in order not to confuse this formula with any other I propose to name it

‘Soda and Potash Sprayfluid’ (Strawson).

Take of—

Soda crystals (soda carbonate) 98 per cent. .	2½ lb.
Potassium carbonate 80 per cent. (or its equivalent)	1 lb.
Lime, fresh burnt	2½ lb.
Soft soap (8 per cent. potash)	½ lb.
Water to make 10 gallons.	

Place the lime in a suitable vessel, slake it with a little water to a fine powder, then add about 1½ gallon of water and mix into a creamy liquid. In this dissolve the soda and potash. Stir well for a few minutes, then pour in the remainder of the water (in which the soap has been previously dissolved), and allow the coarse particles of lime to settle and the sprayfluid is ready for use. A considerable excess of lime should always be used to ensure the soda and potash being converted into the caustic state. Any excess of lime is unimportant, as it merely settles at the bottom of the vessel and does not alter the character of the caustic solution. It is better to use double the quantity of lime if its quality is at all doubtful. After standing, the clear liquid will not effervesce when vinegar or other acid is added to it if the causticising is complete. If the fluid is stirred up and left to stand only a moment the finer particles of lime remaining suspended will form an excellent spraymarker.

The above formula, using 2½ lb. of soda crystals in 10 gallons of water, I suggest as a standard. To alter the strength of the sprayfluid to suit the plant to which it is applied, increase or diminish the first three ingredients only in due proportion. If it is desired to use potassium carbonate instead of caustic potash in this sprayfluid, the soda alone should be put in with the lime to causticise, and after the lime has settled draw off the clear solution of caustic soda and dissolve the potassium carbonate in it.

This modified formula is given because it accords with the earlier practice of applying soda and potash, but the standard sprayfluid which I have designed will probably be found more effectual and convenient in general practice.

11. Potassium Carbonate.

Synonyms :—Pearlash, potashes, potash, wood potash, potash lye, crystal potash lye, subcarbonate of potash, commercial potash, salts of tartar.

Potassium carbonate is readily soluble in water, and is easily obtained in an impure state by dissolving it out of wood ashes and evaporating to dryness, which is one of the forms of crude potash. The list of synonyms given above supplies the chief names under which potassium carbonate of various strengths and qualities are obtained in commerce for fungicidal and insecticidal purposes; the potassium carbonate strength in these varies from 40 to 85 per cent., and they usually contain in addition from 2 to 20 per cent. of soda carbonate. When either of these materials is prescribed, a cheap form of potassium carbonate is intended ; a pure form would be unnecessary and is too expensive. When these varying articles are used indiscriminately serious differences must occur both in the manufacture and in the effect of the preparations made from them. Yet they appear to be largely used indiscriminately, for it is extremely rare to meet with a writer who quotes the percentage of carbonate, and it is still more rare to meet with an employer who knows the actual strength of the potassium carbonate he is using.

Any of these materials may be safely employed if the quantity is proportioned to a fixed standard of strength. Having well considered this matter, I conclude that an 80 per cent. potassium carbonate is generally more economical and more easily obtained. I therefore suggest commercial potassium carbonate of 80 per cent. strength as the standard to be used for insecticidal and fungicidal purposes.

Pearlash, which is refined from crude potash and often contains about 80 per cent. potassium carbonate, is well known and widely distributed, and may be obtained at most oilshops and chemists'. There are several other ambiguous names for potash salts employed in the United Kingdom, Canada, and the United States, such as 'concentrated lye,' &c., but I have been unable anywhere to meet with any reliable information of their exact composition. It would be very useful if someone well acquainted with the local names of these articles would give a list of them and the percentage of pure potassium carbonate or caustic potash contained in each, and thus make it possible for others to understand the formulæ in which they are named.

12. Potassium Sulphide.

Synonyms :—Sulphuret of potassium, persulphide of potassium, liver of sulphur, hepar sulphur.

By heating potassium carbonate and sulphur in an iron vessel until complete fusion takes place an old-fashioned medical remedy is produced, long known as liver of sulphur. Its chemical composition is complex and variable, being commonly made with commercial pearl-ashes.

It consists chiefly of potassium sulphide, upon which its valuable fungicidal properties depend.

Exposed to the air it rapidly decomposes, and should be stored in well-secured, air-tight vessels. With this and other articles that cannot be exposed to the atmosphere without deterioration it is advisable to have them put up in comparatively small packages, so that the whole contents of a package may be used at once and the remaining stock left intact. It is a powerful, useful fungicide and possesses some fungifugal properties, but care must be taken to adjust the strength of the solution to the susceptibility of the plant, and from 1 oz. to 10 oz. in 10 gallons of water will probably cover all requirements.

For general purposes the following strength is suitable to hardy plants :—

Potassium sulphide . . .	. 5 oz.
Water	. 10 gallons

Dissolve.

Spraymarker.—Plaster of Paris in very small quantity.

13. Lime.

Synonyms :—Slaked lime, calcium hydrate.

The common lime (slaked lime) which it is necessary to use for fungicides and insecticides is extremely variable in composition. The limestones, from which it is made by burning in kilns, are composed chiefly of carbonate of lime with some impurities varying with the quarry from which it is taken. The impurities in parent stone will be found transferred in nearly the same proportion in its offspring, lime.

The inconvenience of this may be anticipated in some degree by obtaining the full analysis of an average sample of the lime produced from the local kiln.

A further difficulty arises from avidity of caustic lime and slaked lime for carbonic acid. As soon as the caustic lime is removed from the hot kiln and exposed to the atmosphere it commences to attract water and carbonic acid from the air, and this process goes on incessantly until it becomes 'air-slaked lime.' The absorption of carbonic acid still continues until the lime has reverted to carbonate of lime—the chemical form in which it existed in the limestone. Seeing that lime degenerates by degrees until it reaches a permanent state of uselessness as an insecticide, it is safer to use only freshly burnt caustic lime, and slake it from time to time when required for use. Caustic lime may be kept perfectly good for a long time if entirely closed from the atmosphere.

In selecting lime, lumps are preferred to the powder, and lightness in proportion to bulk is a rough criterion of its quality.

It is of the greatest importance in some cases to have the lime in the highest possible state of subdivision. The ordinary method of slaking caustic lime is to place it in a heap and freely sprinkle with water. After a short time it evolves heat and falls to a fine powder (calcium hydrate).

Lime is capable of being produced in a far higher state of subdivision than by the ordinary practice. The writer had occasion some years ago to investigate this subject, and produced results far beyond expectation by a simple and practical method. As the value of lime for some insecticidal purposes is much increased by its fineness, it may be an advantage to give an outline of this process.

Freshly burnt chalk lime of the purest quality was obtained and broken into lumps of uniform size, about 4 oz. each, and the rest rejected. Each lump was then held under water for about eight seconds and placed on a clean dry wooden floor. When all the lime had been so treated the heap was covered with a light cloth and allowed time to thoroughly slake, and whilst still hot and dry passed through a very fine wire sieve to remove any cores of calcium monoxide or other coarse matter, and finally secured in air-tight tins for use. This lime when blown into a cloud from a glass tube and allowed to settle on a bright black surface appeared to have reached a state of subdivision that was unlikely to be capable of improvement by simply slaking. The bulk almost assumed the property of liquids in being nearly able to float to a level surface of its own accord.

By one step further these fine particles of lime can be reduced to probably twenty times higher subdivision. By adding strong vibration to an air blast and feeding the lime into it, all the weakly cohering, minute particles, or those which had a tendency to conglomerate, were separated, and showed remarkably improved subdivision on the black testing surface.

As a practical illustration of what may be done in the distribution of finely prepared lime as a fungicide or insecticide, 7 lb. of such lime has been blown into a large dense cloud, which has taken ten or fifteen minutes to settle, whilst it has drifted over more than two acres of land, with the result that every tree and plant and leaf has been so completely coated with a film of lime that space could not be found anywhere on the two acres where a pin's point could be placed without touching lime.

This method of distribution is commended to the notice of those who are concerned with the maladies of those vast areas of vegetation which are not amenable to a treatment by an ordinary system of applying remedies. This sketch merely shows what perfect distribution may be done by careful preparation of material. Probably arsenical and other powerful agents might be found workable with lime and applied in any suitable quantity.

14. Bordeaux Mixture and 'Strawsonite,' or Copper Lime Sprayfluid.

Bordeaux mixture is formed by decomposing copper sulphate with lime. The following may be regarded as a standard formula:—

Copper sulphate (98 per cent.) . .	2 lb.
Lime (freshly burnt)	1 lb.
Water to make 10 gallons.	

The copper is dissolved in one half of the water. The lime after being slaked to a fine powder is well mixed with the rest of the water and then poured into the copper solution and stirred. If the lime has been of a good quality and freshly burnt the mixture is complete, but must not be relied upon without careful testing. The quality of lime, unfortunately, is ever variable, therefore every fresh quantity of mixture must be tested when made. To test this, blue litmus paper is convenient. After the copper precipitate has settled the litmus is dipped in the clear, supernatant liquid. If it remains blue the liquid is satisfactory; if it turns red a little more lime must be added, the liquid stirred, and the test repeated until the litmus remains blue when dipped.

Another and safer test for the presence of copper in the clear liquid is the potassium ferrocyanide test, applied as follows. After the lime and copper has settled in the mixture, place a little of the clear fluid in a shallow cup or dish of white porcelain and add a little of a 10 per cent. solution of potassium ferrocyanide.

If a brownish precipitate appears there is copper sulphate still in solution, and more lime must be added and the test repeated until the liquid is found free from copper. The mixture must then be carefully strained to make the sprayfluid, and constantly agitated whilst in use to keep the sediment in suspension. The freshly prepared mixture gives a slight temporary shock to the plant when first applied, and no doubt this is generally the case, but less observable in some instances than others.

In practice I have every reason to believe that the smaller the quantity of lime used the better, so long as the sulphate is all decomposed. In working on a large scale I certainly have observed better results where the lime has been reduced to the lowest practical point.

Several experiments have been tried with the view of making this mixture adhere more firmly to the leaves, but no important advantage has resulted therefrom. For instance, the mixing of molasses or treacle has been tried almost from the first introduction of the mixture, and is still occasionally advocated in theory, but it is well known to practical men to be rather injurious than beneficial, and is an unnecessary waste and trouble.

Other copper compounds, such as copper oxide, Burgundy mixture, in which soda carbonates are used, are employed as substitutes, but all these are unquestionably inferior in practice either to Bordeaux mixture or 'Strawsonite.'

15. 'Strawsonite.'

All the elements of a very pure Bordeaux mixture except the water are contained in 'Strawsonite,' the water being added at the time of using. It is in the form of a fine greenish powder, and is a stable chemical compound of copper of uniform strength (24·4 per cent. pure copper), and not being injured by damp or exposure will keep good for any length of time. It offers great facilities for spraying by its extremely convenient and reliable qualities. It merely requires mixing with water to be ready for use, 2 lb. in 10 gallons of water forming the ordinary 2 per cent. mixture.

An important feature in 'Strawsonite' is that it does not give that severe shock, when applied to the tender green leaves of plants, that is so often injurious with freshly prepared mixtures. This good quality has been very extensively demonstrated over several years' practice on the largest field crops. Its economic value is widely acknowledged, especially where a large acreage has to be dealt with. It saves time and labour and the risk of inaccuracy in compounding, which frequently leads to considerable loss. It is packed in strong bags, and a measure with directions for use is included in each bag. The material is measured into the water, stirred up, and passed through the strainer into the sprayer.

'Strawsonite' was first made in 1893, and accepted in 1895 by the Congested Districts Board of Ireland in the first extensive attempt to educate farmers in spraying potato crops. It is now used by the principal growers in the United Kingdom and by many in the Colonies. The real article must not be confounded with the several imitations of 'Strawsonite' now on the market, varying from 20 per cent. to 50 per cent. below strength. The best guarantee against lower qualities is to demand, as in all similar cases, the article itself and not a substitute. It is of a fine greenish blue, and not a dark leaden colour. For convenience of handling it is put up in bags of 10 lb., 20 lb., 40 lb., and 100 lb. each.

16. Ammoniacal Copper Sprayfluid.

Take of—

Copper sulphate (98 per cent.) . .	1½ oz.
Soda carbonate (98 per cent.) . .	1¾ oz.
Ammonia solution (strongest) . . or sufficient	12 fl. oz.
Water to make 10 gallons.	

Dissolve the copper and soda separately, each in half a gallon of water, pour the soda into the copper solution and stir well. Let it stand a few hours to allow the precipitate to settle, and pour off the clear liquid. Wash the precipitate again by adding more water, and when the precipitate is well deposited pour off the supernatant clear liquid. Then introduce sufficient liquid ammonia to the precipitated copper carbonate to dissolve it, taking care not to use any unnecessary excess of ammonia. To this add water to make up 10 gallons, and the sprayfluid is ready for use.

This sprayfluid may be kept in the concentrated form after the solution in ammonia is completed, but must be preserved in well-stoppered bottles; the water can be added when required.

This fungicide is used for similar purposes to Bordeaux mixture and 'Strawsonite,' and is especially applicable where it is not desirable to colour the fruit or foliage, as it leaves only a slight mark.

17. **Copper Sulphate** (98 per cent. pure).

Synonyms:—Bluestone, blue vitriol, blue copperas, cupric sulphate.

In addition to the above synonyms, this sulphate is frequently sold as 'agricultural sulphate of copper.' Those who purchase under this name must be prepared to find it adulterated with iron sulphate, sometimes to the extent of more than 50 per cent. Copper sulphate of 98 per cent. purity is obtainable in commerce everywhere. Buyers are strongly advised to purchase only under that name and quality, avoiding the use of synonymous terms, which frequently cover an impure article. It is met with in hard, stony, bright blue crystals, hence the common name 'bluestone.' In this form it has been made for centuries, and is still largely manufactured in the same form, which is very slowly soluble in cold water, but more readily in boiling water.

Some years ago I devised a new process for the manufacture of copper sulphate, producing it in minute soft crystals, which dissolve as quickly when stirred in cold water as the old form does with boiling water. This is found to be an important advantage when required to be used in large quantities in the field, as it can be dissolved in the quantities required in a few minutes in cold water.

Copper sulphate is a corrosive irritant poison. In solution it is quickly decomposed if brought into contact with iron or zinc, for which reason the ordinary metal pails or vessels should not be used in connection with it, wooden or earthenware being more suitable. It is used as a fungicide for pickling seed corn as a preventive of smut and other fungous diseases, four ounces dissolved in one quart of water being sufficient for wetting one bushel of either wheat, oats, barley, or rye. Its most important use is in the preparation of various fungicides. Copper sulphate is seldom sprayed on foliage as a fungicide, but weak solutions of ½ or 1 per cent. are occasionally used on dormant trees.

Sulphate of copper is now largely used for destroying charlock (*Sinapis arvensis*) in corn crops, for which purpose it has proved a specific. The quality of copper sulphate known as the Charlock brand possesses considerable advantages for this purpose.

18. Iron Sulphate.

Synonyms :—Green vitriol, green copperas, copperas, ferrous sulphate, protosulphate of iron.

The iron sulphate of commerce in pale green crystals is sufficiently pure for plant maladies, and possesses considerable fungicidal properties. When employed as a sprayfluid it is extremely disagreeable to use, and has a bad character with the workman; it frequently destroys the clothing and causes so much personal discomfort that they refuse to continue using it. For this reason alone it is advisable to replace it with other fungicides where possible. An acid solution made as follows is successfully used against grape anthracnose.

19. Acid Iron Sulphate Paint (for anthracnose).

Take of—

Iron sulphate	40 lb.
Sulphuric acid	2 lb.

Hot water to make 10 gallons.

Dissolve the sulphate in a wooden vessel and add the acid. Used as a paint for vines and the supporting stakes to prevent anthracnose.

Its application for other purposes, such as canker on fruit trees, &c., will be more suitably dealt with in Part No. 2 of this work.

20. Sulphur.

Synonyms :—Sublimed sulphur, flowers of sulphur.

Sulphur is an elementary substance, entirely volatile, without residue at high temperature, and very slightly volatile at ordinary temperature. It is usually met with as a bright yellow powder, known commercially as 'flowers of sulphur.' It is insoluble in water but soluble in bisulphide of carbon. Fused with potassium carbonate, it forms the valuable fungicide, potassium sulphide. Sulphur is employed chiefly for fungous diseases, but it also possesses some insecticidal properties. It is used against mildews on vines, hops, strawberries, and other crops by dusting it over the leaves. Being non-poisonous, its harmless nature on some fruit crops is much in its favour. The action of sulphur is mild and slow, and better suited to lighter fungous attacks, while for more virulent diseases it can generally be replaced with advantage by the copper salts and other more energetic fungicides.

21. **Quassia** (the wood of *Picrena excelsa*).

Quassia is usually obtainable in the form of chips cut from logs by machinery. The chips should be of a clear yellow colour and dry. When damp, quassia soon mildews and becomes of a pale greyish colour from fungous growth, and loses much of its bitterness and value. In purchasing, the colour and intensity of bitterness are the safest guides to good quality. Its bitter, active principle is soluble both in cold and hot water. If it is infused in cold water it should be immersed for at least 24 hours, with occasional stirring. If in hot water, it should be boiled at least one or two hours. Soft soap is generally dissolved in the water and boiled with the quassia to assist the extraction of the bitter principle and to add to its insecticidal value.

The following is a good formula for quassia sprayfluid:—

Take of—

Quassia (in thin chips)	1 lb.
Soft soap (8 per cent. potash)	1 lb.
Water to make 10 gallons.	

Boil the quassia with half the soap and half the water for one hour. Strain off the liquid and boil the residue for one hour with the rest of the soap and water. Mix the two decoctions and make up to 10 gallons with water.

Quassia and soft soap decoction is chiefly used upon hops, and is applied by a machine issuing strong jets of liquid, which strike under the leaves and wash them. It is quite a different operation from spraying, but it is probably from hop-washing that the inappropriate term of ‘washing’ is sometimes used to describe spraying. Except in the case mentioned, quassia is little used on large cultivations.

The insecticidal or insectifugal value of quassia, especially as applied to hops, is probably far less than is generally thought. I should like to see a thorough and impartial investigation on this point, and should not be at all surprised if it was found that quassia could be efficiently replaced with advantage and economy.

Spraymarker.—Whiting (carbonate of lime).

22. Soft Soap (containing 8 per cent. potash).

Synonyms:—Black soap, whale-oil soap, train-oil soap, fish-oil soap, potash soap.

This useful insecticidal soap is the result of saponifying oil with potash, hence the name 'potash soap.' It dissolves readily in boiling water, but with some difficulty in cold water. A good soft soap for insecticidal purposes should be free from resin and contain not less than 8 per cent. of potash. When resin is present in the soap it is apt to separate on dilution into flocculent sticky particles, which clog up the small tubes and orifices of the spraying machine and cause inconvenience.

The names 'train-oil soap,' 'whale-oil soap,' or 'fish-oil soap' are still frequently employed in connection with this soap. Formerly, when train oil or whale oil was of much more commercial importance than now, soft soap was made entirely from it. At the present time soft soap is usually made from other fixed oils, which from an insecticidal point are equal in every respect to train-oil soaps. So far as my own experience goes I give preference to soft (or potash) soaps over hard (or soda) soaps for all spraying compounds.

23. Pyrethrum.

Synonyms:—Persian insect powder, Dalmatian insect powder.

This ancient, effective, non-poisonous, and inoffensive insectide is the pyrethrum flower ground to a fine powder. That which is prepared from the unopened bud is much superior to that prepared from the opened flowers. Both are obtainable in commerce. The former, though quite double the price of the latter, is not distinguishable from it in appearance or by any except practical tests. It should be purchased only from firms of reputation. To make certain of obtaining the powder in the best quality for experimental work and unadulterated I imported the finest unopened buds and had them carefully ground, and found this powder very efficient, but rather too costly. It is rarely employed on large areas, the price being prohibitive. It can be used by simply dusting over the plant, or made into a sprayfluid as follows:—

Take of—

Pyrethrum	2½ lb.
Hot water (not quite boiling) .	10 gallon.

Infuse for two hours, stirring occasionally, and strain out the insoluble matter. Or where the appearance of the dried powder on the plant is not objectionable, it may be thoroughly mixed with water and sprayed without straining.

24. Hellebore Powder (the root of the *Veratrum album* reduced to fine powder).

Synonym :—White hellebore.

White hellebore root ground to a fine powder is an effective poison for leaf-eating insects, and is especially convenient for applying to edible fruit crops, as, unlike arsenical compounds, its toxic effects are dissipated in a few days by exposure on the plant to the effect of the sun and air. Fruit should not be gathered within seven or ten days after the application of hellebore. The active principle of white hellebore is due to a poisonous alkaloid named Veratria. The plant needs to be grown in a suitable climate and soil to yield the full amount of its active principle. As hellebore powder gradually loses its strength by keeping, it should be obtained as fresh as possible and be never more than one year old. Any adulteration would be troublesome to detect, and the best plan is to purchase only from a reliable source.

Hellebore powder is extremely irritating to the nostrils; the dust arising from it should not be inhaled. The best method of applying the powder is by means of a powder distributor or sulphur pump, but it is very commonly distributed by hand on low bushes, by tying it up loosely in sacking and shaking it over the plant.

A more economical way is to use it as a sprayfluid made as follows:—

Take of—

Fresh white hellebore powder . .	2½ lb.
Water to make up 10 gallons.	

The hellebore should be well incorporated with the water, and kept in even suspension whilst being sprayed.

25. Paris Green

is an arsenical insecticide and a powerful irritant poison.

It must not be confounded, as is frequently the case, with Scheele's 'Green'; its chemical composition is different. In this article there is one excellent standard preparation known and used all over the world as 'Blundell's Paris Green,' manufactured by Messrs. Blundell & Spence, Limited, of Hull and London. This is prepared expressly for insecticidal use in two forms: (*a*) in fine powder; (*b*) in paste. The paste is safer to handle than the powder, which is easily blown about. It is also more finely divided, and therefore requires less agitation to keep the sprayfluid of uniform strength. During use it must be kept well suspended in the liquid containing it, or the mixture will be too strong at the bottom of the vessel and may scorch the leaves, and too weak at the top and be ineffectual.

'Blundell's Paris Green' is not soluble in water; neither is it acid, and therefore requires no lime mixed with it. Lime decomposes well-made Paris Green and impairs its usefulness. Several writers have advised the mixing of lime with Paris Green to neutralise a supposed acidity. This is an error. Therefore mixing lime with it should be avoided with well-prepared Paris Green.

When the leaves are injured with Paris Green it is probably owing to its being used as a 'wash' instead of a 'sprayfluid,' or unskilfully sprayed. In this case the use of the words 'Paris Green Wash' is very objectionable and misleading, as Paris Green should never be used as a 'wash,' but only in the form of the very lightest and finest spray, so that the leaves are covered as with a light dew that does not run into drops on their lower edges.

The use of a good and uniform spraymarker is very desirable here, and the spray-mark on the plant should be frequently observed to see that the quantity and quality of the spraying is uniform.

The strength of a 'Paris Green Sprayfluid' must be regulated by the tender or hardy nature of the plant subjected to it. A variation of 10, 20, or 30 per cent. under or over the standard formula given will probably cover all requirements.

26. Standard Paris Green Sprayfluid.

Take of—

Paris Green (Blundell's, either paste or powder)	1 oz.
Water	10 gallons.

Keep the Paris Green uniformly suspended in the liquid during use by constant agitation.

Spraymarkers for Paris Green :—Common whiting (carbonate of lime) or sulphate of lime (plaster of Paris).

Neither of the above decomposes or interferes with the action of the Paris Green, and may be used in sufficient quantity to leave a distinct mark on the foliage, indicating the quantity of material used and the quality of the spraying. With ordinary care there is no danger arising from the toxic qualities of Paris Green. Even with fruit recently sprayed the consumer would have to eat some bushels before he had taken as large a dose as is prescribed in medicine, and as fruit is never gathered for some considerable time after spraying with Paris Green, there is either no trace of it left or the quantity is entirely negligible. Neither is there any danger in feeding sheep or cattle on the grass under trees sprayed with Paris Green.

The ordinary precautions as to the guarding and storage of poisons applies to Paris Green, and the operator should be careful not to inhale the light misty spray whilst using it.

27. Arsenate of Lead Sprayfluid.

Take of—

Acetate of lead (98 per cent.) . .	$2\frac{3}{4}$ oz.
Arsenate of soda (98 per cent.) .	1 oz.
Water to make 10 gallons.	

Place the materials in the water and stir till dissolved, and it is ready for use. One pound of treacle may be added if thought useful.

This sprayfluid is used as a substitute for Paris Green for leaf-eating insects, and adheres more firmly to the leaves than Paris Green. This is a decided advantage, especially on non-edible parts of plants, but in the case of ripening fruit this adhesion is a slight disadvantage, although there is no danger of poisoning the fruit, the quantity of poison being so infinitesimal.

The special advantage of arsenate of lead over Paris Green is that it does not scorch the foliage, even when used in eight or ten times the usual dose.

This sprayfluid is slightly self-marking on the leaves, but the addition of a spraymarker is, I think, an advantage. For this purpose plaster of Paris (anhydrous sulphate of lime) may be added in sufficient quantity.

The lead arsenate sprayfluid may be combined with Bordeaux mixture or ‘Strawsonite’ to form both a fungicide and insecticide.

Spraymarker.—Lime sulphate.

28. Kerosene Emulsion.

Synonyms:—Paraffin emulsion, petroleum emulsion, coal-oil emulsion, rock-oil emulsion.

This most useful insecticide has been sadly abused by introducing it to the public in many fantastic forms, which are still being copied out and circulated. All that is required is a perfect emulsion of a definite kerosene strength that will keep perfect for years and be always ready for use. Fortunately there is no novelty or difficulty about this.

The Hubbard-Riley formula, published many years since, leaves nothing further to be desired, and certainly may be recognised as the standard for kerosene emulsion.

29. Hubbard-Riley Kerosene Emulsion.

Take of—

Kerosene	2 gallons
Boiling water	1 gallon
Soft soap	½ lb.

Dissolve the soap in the water, and whilst boiling hot pour it into the kerosene and beat it up into a creamy liquid. Then pump it with considerable force (not less than 20 lb. to the square inch) through a fine spray nozzle into another vessel. This operation so completely emulsifies the oil that it will not separate for years. Allowing for the evaporation of some water in making, two-thirds of its bulk will be kerosene. If well made, a small portion poured on a sheet of clean glass and immediately washed off with water should leave no oily trace of kerosene on the glass.

The quantity of water used in this formula is rather in excess of the quantity needed to make a perfect emulsion, but it is desirable to retain the exact quantity given, as it is convenient to know that every three parts by measure contain two of kerosene. If after standing some time a little of the water separates, it is only necessary to stir it up before using, and the original proportions are restored.

To form a sprayfluid it is merely diluted when required with from four to fifty times its bulk of water according to requirements. Kerosene emulsion is sometimes used as a paint, diluted with two to six parts of water.

In practice I have generally used double the amount of soap in Riley's formula, but I shall not advise it to others. I have had the pleasure of discussing this matter with the late Professor C. V. Riley, and I conclude that his formula is good enough for all time, and I trust it will always bear his honoured name.

30. 'Vaporite (Strawson).'

The new gas process of vaporising the soil for the destruction of all kinds of soil-insects has rapidly risen to a high position, as I had confidently anticipated it would, as soon as the public had an opportunity of realising its value in extensive practice.

It stands out alone in being the first and only insecticidal method capable of being effectively employed on an agricultural scale to destroy the omnipresent injurious insects that operate in the soil. The nature of the process enables it to accomplish this without the slightest injury to the plant. It goes still further, it not only destroys injurious insects, but many insect-like creatures, such as the microscopic eelworm, which infests the soil near the roots of numberless crops.

The destruction caused by soil pests, for which there has hitherto been no efficient remedy, is almost incalculable.

My particular attention having been directed to this matter for many years, leads me to the conclusion that the soil-insects alone are the cause of more injury to cultivated crops than all others that operate above ground.

It is certain that in unnumbered instances the weakness of the plant by root injury is followed as a direct result on the upper part of the plant by insect or fungus injury.

It may appear to some of my readers that I am not only enthusiastic, but somewhat exaggerating, in my statements. Let me at once assure them that there is no ground for such views, as I speak from a knowledge gained from long practice and confirmed by extensive and careful cultivators. How can I, in justice to those whom I am seeking to benefit, hide from them the facts that are known to me by a wide and practical experience?

Of the many crops to which vaporising has been applied, in some it has saved the whole crop, and in others it has more than doubled their value. All cultivations appear to be subject to the beneficial influence of this process. Corn, turnips, potatoes, carrots, cabbages, olive trees, vines, hops, ground-fruit crops, fruit trees, tomatoes, and cucumbers, and all crops grown under glass, and nearly every kind of garden plant, have already acknowledged the saving influence of vaporite on infested land, and heavy and perfect crops have been produced on land where it had been found such crop could no longer be successfully grown.

Many farmers have jumped to the conclusion that vaporite is a fertiliser, on account of the improved appearance given to the crop.

That it often produces such an appearance on the plant as might be expected from the use of a powerful fertiliser is due to its removing the cause of injury to the roots, and increasing the vitality of the plant. In support of a theory that I have long held, a number of well-defined cases have come before me where such results have been produced without my being able to determine what insect or insects had been destroyed. Let me give one example. In the middle of a large turnip field, where finger-and-toe was anticipated, a square acre was vaporised. When the crop was fully grown, this square acre was distinctly visible from any part of the field, as the leaves were taller and the roots finer. At the time of inspection I was assisted by some gentlemen in trying to find out what enemy had been destroyed to account for the difference. Finger-and-toe did not appear in any part of the field that year and therefore could not be the cause. Neither could we trace any insect injury to the roots, neither wireworms nor grubs were traceable in the vaporised or unvaporised portion of the field. Those who accompanied me held that the difference in the crop could only arise from the material being a fertiliser. This I know it is not, and I believe it is to be explained by a theory I hold, which is that the number of minute injurious insects (and fungus pests) is far greater than is generally supposed. On every kind of cultivated plant we only know of a few injurious insects or insect-like creatures that infest the soil and damage the roots. On any single crop these pests that we know of might easily be counted on the fingers, but what of that vast multitude of minute insect races numbering hundreds of thousands? Do none of these ever commit injury to the roots of plants? If they do, we know nothing or almost nothing of the exact injury done or the pest that commits it.

As an instance of these invisible enemies, take the Eelworm (*Tylenchus devastatrix*); it is practically untraceable in the soil, and is only proved to exist in the soil by circumstantial evidence—when it leaves the soil and enters the tissue of the plant it is easily detected by the microscope. The destruction of this pest in the soil naturally gives an improved appearance to the crop, but I have seen cases of marked improvement, which in all probability did not arise from the destruction of eelworm, but some other microscopic pest or pests, of which I have no knowledge. I therefore conclude that we have much to learn in this direction, and that the effect of this gas process indicates the presence of creatures injurious to plants that science has not yet taken account of.

Here is an interesting field for investigation, a subject that can never be cleared up by mere book-writers or arm-chair scientists.

Fortunately vaporising does not destroy

earthworms. Active creatures such as these are able to move away as soon as they begin to feel its influence.

So far as I have reached at present the benefit of this gas process—vaporising—is almost entirely confined to the destruction of insect and insect-like creatures that infest the roots of plants. It does, however, already go something beyond that, as in some cases it prevents fungus disease. As fungus disease very commonly follows insect attack, it is most likely that the beneficial action of vaporising in relieving plants from fungus disease arises from absence of such root injury as would be caused by soil pests.

I will now give some account of the principles of vaporising and directions for its practical use on various crops, in the form of vaporite.

Vaporite is a gas-producing material which, when distributed broadcast over the land and ploughed or dug in, very slowly decomposes, by the influence of the soil, and gives off a noxious gas. This noxious gas gradually increases in quantity and fills the interstices of the soil and provides an asphyxiating atmosphere in the soil, that cannot support insect life. To accomplish this without injury to the plant is effective vaporising.

Scarcely anything can be imagined more simple and effectual than this method of destroying insects on the soil. There is no skilled labour required. Those who can sow broadcast and handle the plough or the spade are masters of the work.

There is no particular season for applying vaporite; it may be simply used when most convenient or most likely to benefit any special crop. The time when ploughing and digging are going on, in preparation for planting, is both a convenient and also a suitable time. The great principle to keep in mind is that the gas-producing material must be buried deep enough in the soil and covered up, so as to prevent, as far as possible, the unnecessary waste of the gas evolved.

The above principles apply in vaporising all plants; but where neither the plough nor spade can be used for burying the vaporite another means can be adopted. For instance, on vines, fruit trees, and many other plants it is often desirable to dibble in the material, so as to properly insert it in the soil, without deranging the roots. The dibble should be inserted deep enough to go below the fibrous roots, so that the gas may rise and destroy the pests feeding upon them.

The number of holes made round each plant must vary with circumstances; for a vine and like plants, growing in the open, probably four or five holes round the stem and about 18 inches away would suffice. Where the roots grow in a clump, one deep hole passing right down below the centre of the clump would be sufficient.

When vaporite is dibbled, the holes should be covered up and the top firmly pressed down, to prevent any escape of gas.

Vaporite should not be put upon the wet green leaves; it is not intended to be used on foliage of any kind.

It is found in practice that for ordinary ground crops 2 cwt. (224 lb.) per statute acre is sufficient, always remembering that in a stiff cold soil vaporite acts more slowly than in a light warm soil.

Vaporite should not be mixed with any artificial manure, but sown alone; if sown separately and mixed with the soil it is not incompatible with either artificial manures or farmyard manure.

For the guidance of those who are yet unacquainted with vaporising, I will give a few examples of the quantities, &c., to use on different crops, and from these may easily be deduced the dose, &c., for any special culture not named.

FOR CORN CROPS (Wheat, Oats, Barley, &c.). When ploughing the last time before sowing the corn, broadcast and plough in about 2 cwt. per acre (for wireworm, grubs, eelworm, &c.).

FOR ROOT CROPS (Turnips, Carrots, Mangels, &c.).—The same as for corn (for various injurious insects).

FOR BEANS, PEAS, TARES.—The same as for corn.

FOR POTATOES AND LIKE CROPS.—Two to three hundredweight per acre, ploughed in well in advance of planting (for wireworm, grubs, &c.).

For Green Crops (Cabbage, Salads, &c.).—Two to three hundredweight per acre, ploughed in before planting out (for all sorts of grubs).

For Hops and Fruit Bushes.—About 2 cwt. per acre, worked deeply into the soil at the time of cultivation, adding a little extra dose near the plant (for all sorts of soil pests).

For Vines.—Whilst dormant make holes with an iron bar to the depth of the roots, put in about 1 oz. vaporite, and close the top of the hole with earth. Repeat this in four or five places, 18 inches or 24 inches apart.

For Gardens Generally.—Sprinkle 1 lb. over every 10 square yards before digging (to clear off all soil insects).

For Grass Land [Clover Leys &c.).—Two to three cwt. per acre, sown broadcast and ploughed in. If the soil turns up rough and uneven, the surface should be levelled by harrowing to keep in the gas.

For Surface Caterpillars (Grubs, &c.).—Two cwt. per acre, cultivated 3 to 5 inches into the soil.

For Slugs.—Vaporite kills slugs by contact, and may be spread on the surface and raked into the soil.

For Ants.—Make a deep hole with an iron bar in the centre of each anthill and put in about 1 oz. of vaporite and close the top of the hole with earth. Vaporite sprinkled on lawns or grass will drive all ants away.

For Greenhouses (and indoor culture).—Work a little into the soil at any convenient time.

For Cotton, Coffee, Tobacco, Sugar-cane, and all plants liable to insect or eelworm attack.—Apply according to some of the above examples.

For Trees.—Make holes in the ground as deep as the roots and about two feet apart; into each hole put about 1 oz. of vaporite and close the top of the hole firmly with earth.

For Potting Soil.—Mix 1 lb. or 1½ lb. to each cartload (about 1 cubic yard) and allow it to rest three or four weeks before using.

These directions should be sufficient to cover nearly all kinds of vegetation, but should there be any exceptional cultivations, a modified plan may be devised.

Instructions for using it against specified insect pests, and a fuller description of vaporising are given in my recently published book, 'Insects and Fungi on Plants, with Remedial Treatment' (Simpkin, Marshall & Co.).

The imperfect lines that I have written do little justice to a subject of such outstanding importance. What it has achieved and what it is now achieving in this country and beyond the sea, it can achieve equally in all countries and all climates and on all plants. Such a simple, inexpensive but effective remedy against all injurious soil-insects is entirely unprecedented, whilst it is already adding to the wealth of those employing it. I believe vaporising is capable of adding millions of pounds sterling per annum of extra profit to the growers of every country that adopts its use.

Fortunately vaporite is conformable to the requirements of ordinary agriculture: it can be conveyed in light barrels and stored without important loss of strength; when applied to the soil it needs only to be sown broadcast and ploughed in before the seed is sown and the disengagement of vapour commences.

This development is slow, but persistent and effectual. In the cooler early season some time must elapse before a sufficient accumulation of gas is reached to destroy life, and when that point is reached it is probable that it will remain in effective force for some months; but its duration will necessarily depend upon the moisture, warmth, and quality of the soil. In addition to destroying those insects already inhabiting the soil, it does appear probable, indeed almost certain, that those insects which are seeking shelter there for the purpose of hibernating or depositing their eggs would be discouraged by the existing obnoxious conditions.

31. Resin.

Synonyms:—Rosin, black resin.

Resin, which is the product of various species of fir, is too commonly known to need any description here, being universally obtainable. It enters into the composition of one very important insecticide for scale insects. Resin employed as a sprayfluid whilst the plant is in a dormant state is very effectual, but if used on foliage great care is needed to dilute it to a strength that the plant can bear without injury.

Resin sprayfluid may be made as follows:—

Take of—

Resin	4 lb.
Caustic soda 70 per cent. (or its equivalent)	1½ lb.
Fish oil (seal or train oil). . .	2 pints
Water to 10 gallons.	

Boil the resin with 1 lb. of the soda and the oil in two gallons of water until dissolved, then very gradually add one gallon of water in which the remaining soda has been dissolved. Continue the boiling whilst adding slowly the rest of the water, and strain. Where resin sprayfluid is frequently required it is convenient to make it in a more concentrated form by leaving out half the water, adding the remainder when required. I have found seal oil answer well in making this preparation.

Spraymarker.—Whiting.

32. Carbolic Acid.

Synonyms:—Crude carbolic acid, phenol.

The well-known disinfectant, crude carbolic acid, is suitable for insecticidal purposes on account of its low cost. The impurities contained in it are not in this case objectionable, as they are also of insecticidal value. The crude acid is a dark oily liquid—specific gravity 1·05—soluble in solution of caustic soda, forming the soluble carbolic acid which is miscible with water. Carbolic acid, being a dangerous poison, should be carefully stored, and the vessels containing it plainly labelled. When undiluted it should be handled with care, as it causes pain and inflammation in contact with the skin.

There is scope for further investigation with regard to this acid as a plant insecticide, and probably its usefulness would be much extended after a series of well-authenticated trials scientifically carried out, especial attention being given to the proportion and strength of the crude carbolic acid employed.

When used as a carbolic soap dissolved in water, or as a solution in caustic soda, the actual quantity of carbolic acid contained in the liquid is generally unknown or only approximately known ; the results of such applications do not furnish an instructive lesson. Carbolic soaps applied for aphis are sometimes highly spoken of, sometimes quite the reverse. Varying qualities of carbolic soap amply account for this.

I have not had sufficient experience with carbolic acid to recommend a standard strength for general use, and therefore merely suggest the following formula as convenient :—

Hard soap	1 lb.
Crude carbolic acid	2 fluid ounces
Water to 10 gallons.	

Dissolve the soap in one gallon of boiling water, add the carbolic acid, and stir well till dissolved. Add the remaining water at the time of using.

Spraymarker.—Lime sulphate.

33. **Tobacco** (the leaf of *Nicotiana tabacum*).

Tobacco as an insecticide has unquestionable merit, but its employment in agriculture is restricted by fiscal and other conditions in those countries where tobacco is not grown. In the United Kingdom it is a well-known remedy among gardeners, but seldom used in agriculture.

For field use, the most economical method is to make an infusion or decoction and spray it on the plant. By fumigation it cannot be profitably used on large areas.

The strength of the infusion may be varied, but an effectual strength for aphides is :—

Tobacco	2 lb.
Boiling water . .	10 gallons

Infuse for four hours, and strain off the liquid.

34. Lime, Sulphur, and Salt Sprayfluid.

Take of—

Quicklime . .	7 lb.
Sulphur (flowers) . .	3½ lb.
Salt (sodium chloride) .	3 lb.
Water to make 10 gallons.	

First boil half the lime with the sulphur in three gallons of water for about one hour or until dissolved.

Then the other half of the lime is separately slaked and mixed with three or four gallons of water and the salt dissolved in it. Pour this into the sulphur solution and add water to make up ten gallons.

This is for winter application used on dormant trees. It destroys moss and lichen as well as scale and other insects on the bark, and may be applied for the same purposes as the soda and potash sprayfluid. See p. 30.

This sprayfluid possesses fungicidal as well as insecticidal properties.

CHARLOCK

(The Destruction of Charlock in Corn and other Crops).

Charlock (*Sinapis arvensis*) is known locally by other names, as yellow weed, kilk, kedlocks, ketlocks, skellocks (in Scotland), and preshaugh (in Ireland).

Among injurious weeds, insects, and diseases of farm crops, the charlock, the wireworm and the potato disease are kings, and maintain a bad pre-eminence over their kinds. Charlock unquestionably wears the crown as the worst weed. To clothe itself in golden livery where it reigns, it draws a revenue from the farmer, the landlord, and the public, greater than the tax-gatherer and the rate-collector combined. Of the fertility provided in the soil, and of the sunlight and wind, so needful to the welfare of the crops, it ruthlessly takes its moiety. The plant is an annual, but its seed is of such a perennial nature that its vitality, when buried in the soil, survives a hundred years. This has been ascertained by some well-authenticated cases. When the charlock spreads its abundant seed upon the ground and trusts its future to the hand of Nature, some falls a prey to birds, some is intermixed and buried in the soil below its germinative limit. There it sleeps, retaining its vitality for as many years as are necessary, until the return of the friendly plough lifts it nearer the surface, when it awakes and, taking toll of the farmer, arrays itself in all the glory of its ancestors.

I find, by careful experiment on the germination of charlock seed, that only the seed near the surface of the soil can be made to grow. Placed under the most favourable circumstances, no seed would germinate below 1½ inch of the surface, and but few 1¼ inch below. As there is no practical way of getting this seed out of the soil except by growing it, it follows that a good deal of cultivation must take place before all seed that is on the soil can be got rid of. This has been done, and, by preventing re-seeding, land has been cleared. A gentleman told me that he had cleared 1,000 acres of his land of charlock years ago by hand-picking, but that it cost as much as the value of the land. From actual experience of my own I find, in ten years, charlock seed may be grown out of badly infested land, if it is regularly cultivated and no re-seeding allowed, and that after the first four or five years the diminution is so considerable that it gradually reaches a negligible quantity.

I tested the limit of endurance on wheat, of various strengths of solution (50 gallons to the acre) up to 8 per cent., which I expected to show damage, but was pleasingly disappointed, for although it was more than double the quantity necessary to destroy the weed, the corn crop was only stained, but not injured, and finally showed an improvement over the surrounding corn. The prejudice and fear of injuring the corn crop have turned out baseless. In thousands of acres with which I have been concerned annually, I have never seen one corn crop injured. On the other hand, I do not know of one that has not been benefited, and produced extra yield of corn. I believe, taking an average of fairly well infested corn crops, the increased yield of corn arising from the destruction of the charlock amounts to 6 or 8 bushels per acre; but where the charlock has been thick, and well destroyed, I have frequently known an increased yield of barley of 12 to 16 bushels per acre, and in one case of 20 bushels. In the present year this operation is well-established, and over a thousand horse-power machines are now employed for this work in the United Kingdom.

The crops in which charlock can be safely destroyed include all corn crops, such as wheat, oats, barley, as well as beans, peas, tares, mangels, and some others. The young hay seeds, such as grass, clover, sainfoin, &c., growing in the crop, are not injured by the spraying. Cabbage plants and swede turnips have been frequently sprayed without injury, but the treatment of these is at present thought too risky for general recommendation. The staining of the blades of corn is merely temporary, and does no injury whatever to the resulting yield.

Charlock can be destroyed at any period of its growth with copper sulphate, and can as easily be killed when it is just coming into flower as when it is a young seedling; but there is no question as to which time is the most profitable. When destroyed young the corn has the full advantage of the fertility of the soil, and the light and air, and gives naturally a better yield of corn.

The permanent improvement of charlock-infested land should be one of the greatest incentives to systematic spraying. I know from actual results that the old seed in the soil can be grown out to a negligible point in seven or eight years. What I have said on the germination of the seed would lead to this conclusion.

A secondary advantage of no mean importance inevitably follows the destruction of charlock on arable land. Charlock is a host-plant. on which both insects and fungi are sustained during the interval of cruciferous cultivations. The turnip flea-beetle, the mustard beetle, and the slime fungus causing finger-and-toe (or anbury on turnips), are all nourished and supported by charlock, whilst waiting the more liberal supply of food from the hand of the farmer. Therefore this weed should be stamped out, as far as possible, as a preventive of these and other evils.

Copper sulphate has proved to be by far the best and safest material for this purpose. It must be of standard quality, and that which dissolves immediately when stirred in cold water economises time and greatly facilitates the ease and accuracy of field spraying. It is known as the 'Charlock Brand.'

CHARLOCK-SPRAYING BY HAND-POWER FROM AN ORDINARY FARM-CART

Spraying machines worked automatically or by hand with powerful pumps are best.

The two illustrations which follow show the effects of early and late spraying. Fig. 1 is from a field sprayed when the weed was young. A plot was covered at the time of spraying and is now seen in flower, and may be compared with the surrounding sprayed field.

Fig. 2 shows average plants taken from a field of barley, sprayed late in August, when the weed was 18 to 20 inches high and in flower. The operation was perfectly successful and made a remarkable change in the appearance

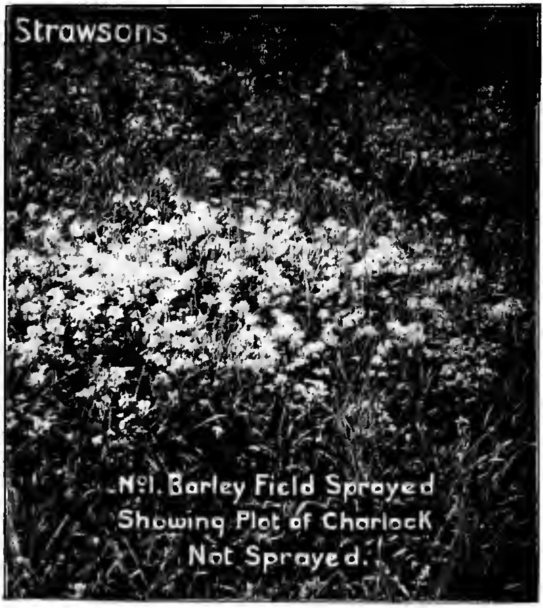

FIG. 1.—SPRAYED EARLY

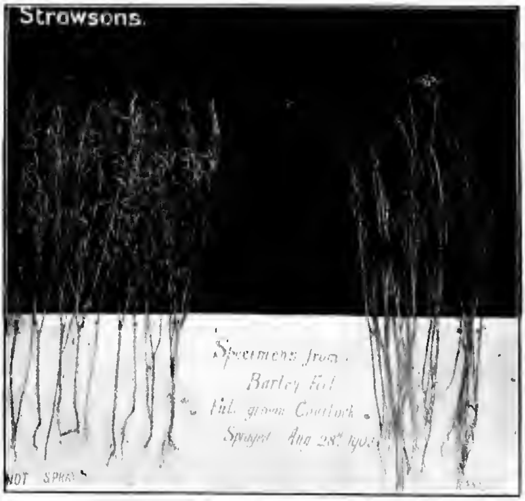

FIG. 2.—SPRAYED LATE

of the field. The plants on the right are like all those in the field that were sprayed, and were seedless and dead. Those on the left were unsprayed and show the prolific seeding of the plant.

I cannot do better than give a copy of my seventh annual report on charlock destruction, as this has only just been published, and is close up to date. It is as follows:—

'April 2, 1906.

'After carefully watching the charlock spraying operations for the past seven years, we have now reached a period when those who have sprayed well and regularly are able to notice a great diminution in the noxious weed, and have probably gone more than half-way to its reduction to a negligible point.

'From personal experience I know charlock can be eradicated from cultivated land, if all reseeding is prevented, in a few years. Many who began this practice early are reaching this desirable point, and are nearing the completion of their work; whilst others, in large numbers, at different stages on the road, are travelling in the same direction.

'The successful destruction of charlock in corn and other crops is now so well known and largely practised that it is no longer necessary to treat it as a newly introduced operation. All who cultivate charlock-infested land should by this time have become acquainted with the process, and it is now only necessary to repeat, for those who have not yet adopted charlock spraying, some of the advantages that arise from it, and give some reliable information that will be a guide to obtaining those advantages.

'The heavy loss occasioned by growing a crop of this weed among corn is fully acknowledged, and is proved by practice to be equal to eight to sixteen bushels per acre. This loss can be avoided and a profit realised by a single spraying in one year; but by repeating the operation for a few years no re-seeding of the land takes place, whilst the old seed in the land is gradually grown out, and the increased annual value of the land becomes permanent.

'Charlock, like the turnip, is a cruciferous plant, and such enemies of the turnip as club-root and turnip flea-beetle are nourished and perpetuated by the charlock during the intervals of the turnip crop, so that the destruction of this noxious weed is all the more desirable.

'These advantages alone should surely be sufficient to induce cultivators to adopt the easy and profitable method now available for ridding their land of this worst of all weeds.

'The object of spraying charlock is to destroy the whole of it, and prevent re-seeding. The operation is sometimes very imperfectly done, arising very commonly from inefficient labour or imperfectly dissolving the copper sulphate.

'The operation is simple, easy and rapid, the difference in cost between doing it badly and in the best way will not be more than 6*d*. per acre; but the difference in result will be that in one case only 60 or 70 per cent. of the weed will be destroyed, whilst in the other the whole of it will be killed except perhaps a few straggling plants.

'The spraying should be done when the crop is dry, and some few hours before rain. The spray should be fine and misty, and the simple directions carried out.

'The following statements are fully confirmed by wide practice, and may be relied upon :—

'1. That young charlock can be destroyed in growing corn crops without injury to the latter by spraying with 50 gallons of 3 per cent. solution of copper sulphate (15 lb. to 50 gallons) per statute acre, and older charlock with a stronger solution.

'2. That the corn crops are much improved, and give a better yield, where the charlock is destroyed, and that young grass seeds and clover in the corn remain uninjured.

'3. That spraying early, when the weed is young and in soft fibre, is most profitable (but it can be quite successfully done just as the weed is coming into flower, or when in flower).

'4. That the larger machines are more successful than the smaller.

'5. That the profit derived from increased yield of corn is diminished in proportion to the delay which occurs after the charlock is first fit to spray.

‘6. That the increased yield of corn, by the destruction of the charlock, leaves a substantial profit after all the expenses of spraying have been defrayed, and that the value of all charlock-infested land increases until the extermination of the weed is complete.

‘I am again indebted to many friends for whose assistance in technical points I beg to tender my most sincere thanks.

‘G. F. STRAWSON.’

LONDON: April 2, 1906.

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"Much and varied information on the subject has been published from time to time, but we now have a volume far superior to anything that has preceded it and carrying the matter to a higher level than ever before. This is Mr. G. F. Strawson's 'Insects and Fungi Injurious to Plants, with Remedial Treatment'(London: Spottiswoode; Paris: Galignani; 200 pages, *3s. 6d.*). No man in this country has done more than Mr. Strawson—no man, indeed, has done so much—to save the crops from destruction and their owners from serious loss. At many places in England and Wales, in Scotland, in Ireland, and also outside the limits of the United Kingdom, he has conducted successful operations directed to the saving of potato crops by spraying; to the rescuing of turnips and swedes from the attack of the 'fly;' to the suppression of pests that infest glasshouses; to the destruction of that most pernicious of weeds, Charlock; and to many other equally desirable objects. The outcome of this extensive experience is this eminently practical volume, which is appropriately dedicated to that veteran agriculturist, Sir Jacob Wilson. The book is likely to prove of the utmost value to all cultivators of crops"

THE NORTH BRITISH AGRICULTURIST, July 19, 1905.

"Mr. Strawson, of 'Strawsonizer' fame, has brought out a new book of outstanding interest and value to the agriculturist and horticulturist. Mr. Strawson is a gentleman who has a high reputation to maintain, and it is not at all likely that he would have published his claim to having made such an important discovery—a cheap and thoroughly efficient means of clearing the soil of all noxious insects by means of a gas—unless he were able to substantiate it."

THE FARMER AND STOCKBREEDER, October 30, 1905.

THE STRAWSON SYSTEM OF TREATING INSECT AND FUNGI ATTACKS.

"'Insects and Fungi Injurious to Plants, with Remedial Treatment,' is the extended title of a volume from the pen of Mr. G. F. Strawson. The author has devoted a lengthened period to the study of the problem how best to combat those natural enemies of agriculture and horticulture—insects and fungi. The theory and practice in the treatment of these pests has undergone not a modification, but a radical alteration within the past decade. Mr. Strawson has been a voluminous experimenter, and those who know him agree that to his theorising he brings much practical experience. Most of us are familiar with the homely devices commonly used for the suppression of soil insect attacks. From these Mr. Strawson breaks away, and his propaganda includes the substitution of the gas process, which, in his own words, is 'a hundred times sharper and more far-reaching.' The use of gas in the suppression of insect attacks from the soil has not hitherto been adopted, and consequently it is expanded in the volume before us with becoming lucidity. The volume is worthy of the closest attention, and preserves as a worthy record the experiences of one who has given himself whole-heartedly to the study of his subject."

THE AGRICULTURAL GAZETTE, August 14, 1905.

"In many respects this book brings new processes into notice, and otherwise puts up-to-date spraying into a compact form, making it the most complete handbook of its kind yet published. The miscellaneous section brings a great amount of valuable information and advice into a comparatively small compass."